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Flight Service Evaluation of Advanced Composite Ailerons on the L-1011 Transport Aircraft

Third Annual Flight Service Report

R. H. Stone

LOCKHEED-CALIFORNIA COMPANY
BURBANK, CALIFORNIA

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July 1985

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FOREWORD

This report was prepared by Lockheed-California Company, Burbank, California under Contract NAS 1-15069. It is the third annual report covering flight service evaluation of composite inboard ailerons on the L-1011 from July 1984 when the second yearly inspections were completed, through June 1985. The program is sponsored by the National Aeronautics and Space Administration (NASA), Langley Research Center. Mr. Marvin B. Dow is the Project Engineer for NASA.

C.F. Griffin is the Lockheed Engineering Program Manager and is being assisted in the flight service evaluation by R.H. Stone.

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FLIGHT SERVICE EVALUATION OF ADVANCED COMPOSITE AILERONS ON THE L-1011 TRANSPORT AIRCRAFT

SUMMARY

Four shipsets of graphite/epoxy composite inboard ailerons were installed on L-1011 aircraft in March through May 1982 for a five-year maintenance evaluation program. These include two Delta aircraft and two TWA aircraft. A fifth shipset of composite ailerons were installed in 1980 on Lockheed's flight test L-1011.

Results of the third annual inspection of these five shipsets of components are reported herein. These were visual inspections of the aileron exterior surfaces.

No visible damage was observed on any of the composite ailerons, and no maintenance action has occurred on any of the parts except for repainting of areas with paint loss. Flight hours on the airline components at the time of inspection ranged from 8787 to 10,804 hours, after approximately three years of service.

1. INTRODUCTION

In 1977 the Lockheed-California Company initiated a program to demonstrate the weight and cost-saving potential of secondary aircraft structures constructed of advanced composite materials. The component selected for this demonstration was the inboard aileron of the L-1011 transport aircraft. The program is sponsored by the National Aeronautics and Space Administration as part of the Aircraft Energy Efficiency (ACEE) Composite Structures Program.

The program scope included the evaluation of alternate designs and materials for the aileron; detail design and analysis; fabrication and test of subcomponents for design verification; fabrication and testing of two ground test ailerons; fabrication of five shipsets of ailerons for installation on L-1011 aircraft; flight testing of one shipset on Lockheed's flight test aircraft; and the 5 year flight service evaluation discussed herein. The overall program is summarized in the executive summary report (Ref. 1). Lockheed's team member on this program was Avco Aerostructures Division of Avco Corporation. Avco was responsible for fabrication of the composite ailerons.

The composite aileron design, shown in Figure 1, is a multirib configuration with single piece upper and lower covers mechanically fastened to the

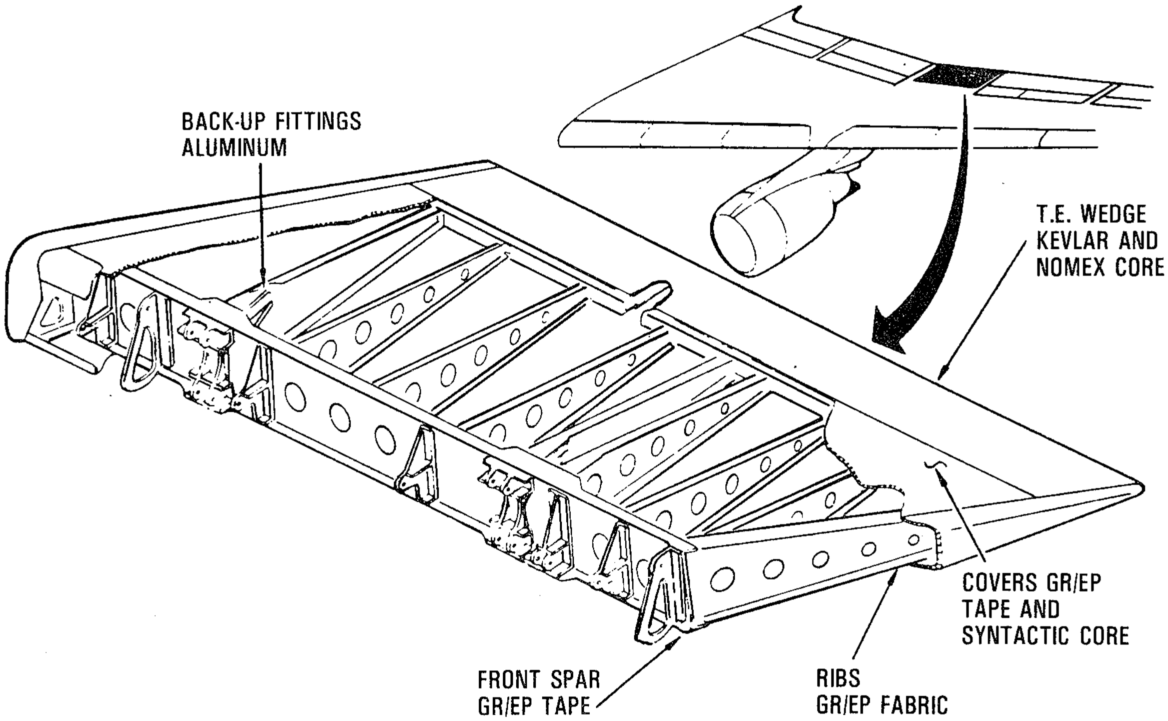

Figure 1. - Advanced composite aileron assembly.

substructure. Three basic materials were utilized in the aileron design: Narmco 5208/T300 graphite/epoxy unidirectional epoxy tape; Narmco 5208/T300 graphite/epoxy bidirectional fabric; and Hysol ADX 819 syntactic epoxy core.

The aileron covers, ribs, and front spar were fabricated using standard vacuum bag autoclave molding procedures. The aileron covers are thin sandwich plates with graphite/epoxy tape facesheets and a syntactic epoxy core. The ribs and spars are constant thickness channel sections, laid up and cured on male tools. The intermediate ribs are fabricated of bidirectional graphite/epoxy fabric. The main ribs which react hinge and actuator loads are fabricated of graphite/epoxy fabric, with the caps reinforced with graphite/epoxy tape. The front spar is fabricated of graphite/epoxy tape laid up in approximately a quasi-isotropic orientation.

The complete aileron assembly includes an aluminum leading edge shroud, aluminum bathtub fittings at the spar to main rib joints, fiberglass/epoxy fairings, aluminum hinge/actuator fittings, and a Kevlar 49/epoxy trailing edge. The composite aileron design is 26% lighter than the metal aileron

and is predicted to be cost competitive since the composite aileron has 50% fewer parts and fasteners than the metal aileron.

The inboard aileron is located on the wing trailing edge between the outboard and inboard trailing edge flaps. It is supported from the wing at two hinge points and is actuated by three hydraulic actuators. It is a wedge-shaped, one-cell box, thinning slightly from root to tip. At the front spar the aileron is 233.7 cm (92 in.) in length and approximately 25.4 cm (10 in.) deep. The width of the aileron is 127 cm (50 in.). The upper surface, ribs, and spars are permanently fastened using titanium Triwing screws and stainless steel Hi-Lok collars. The removable lower surface, trailing edge wedge, and end fairings are attached with the same type screws but with nut plates attached to the structure with A286 Cherry Rivets. All fasteners are installed with sealant. The aileron is primed and painted with standard aircraft materials.

2. FLIGHT SERVICE EVALUATION PLAN

The final phase of the inboard aileron program is a five-year flight service evaluation. A left-hand and right-hand aileron were installed on four new L-1011 aircraft. Two of these aircraft were subsequently delivered to Delta Air Lines, and the two others were delivered to Trans World Airlines. The Delta aircraft were the standard L-1011-1 model, while the TWA aircraft were longer range L-1011-100s.

The evaluation agreement between Lockheed and the two participating airlines consisted of the following elements:

1) The evaluation period is five years.

2) An exterior visual inspection will be performed by airline personnel and witnessed by Lockheed personnel at annual scheduled "C"-check inspections closest to the anniversary of installation.

3) An interior inspection, requiring removal of the lower cover, will be conducted at the end of the five-year evaluation by airline personnel, witnessed by Lockheed personnel.

4) The airlines will provide a written report to Lockheed on the results of each inspection. This report will include inspection results, a description of any maintenance or repair actions, flight hours, number of landings, and utilization rate for the year.

5) In the event visible damage is observed, the airlines will determine the extent of damage by ultrasonic inspection using standards pro-

vided by Lockheed. After notification of Lockheed, the airline will repair the damage in accordance with the L-1011 Structural Repair Manual, which was revised to incorporate specific repair procedures for the composite ailerons.

A fifth shipset of ailerons were installed on the Lockheed flight test airplane as part of FAA certification. These flight tests are described in the Task IV Final Report (Ref. 2). A visual inspection of the exterior and interior aileron surfaces was conducted by Lockheed personnel after the first and second years of flight service. Since the second annual inspection in July 1984, there have been only 10½ hours flight-time and the aircraft is currently inactive. Therefore, no additional inspection was performed this year, and no further inspections are planned unless significant utilization of this aircraft resumes.

3. AILERON FLIGHT SERVICE EXPERIENCE

The first and second annual flight service inspections of the five ailerons shipsets were conducted in March through July of 1983 and April through July of 1984. The results of these inspections are given in the First and Second Annual Flight Service Reports(Refs. 3 and 4). No damage or defects were observed in any of the ten ailerons in those inspections.

The inspection results for the third year of flight service are summarized in Table I, along with utilization rate and aircraft flight-hours and landings as of the inspection date for the composite ailerons. A total of 80,396 component flight-hours were accumulated through May 1985 on the ten installed ailerons. The high time ailerons have accumulated 10,804 flight hours in three years.

The third annual visual inspections of the composite ailerons again revealed no damage, even of a minor nature, on any of the ten components. Minor paint loss was reported on the two TWA aileron shipsets, and touch-up paint was applied. Paint loss of this type is a fairly common occurrence on metal or fiberglass components. The significance for the graphite/epoxy ailerons is: 1) paint loss indicates that the ailerons are being exposed to hydraulic fluid; and the lack of damage verifies the resistance of graphite/epoxy to aircraft fluids; 2) the upper surface is exposed to ultraviolet, and epoxy resins are known to be affected by ultraviolet with significant weight losses after extended exposure. Airline maintenance personnel were advised of the need for repainting of exposed graphite/epoxy, particularly on the upper surface. In the one shipset visually inspected by Lockheed Engineering, it was noted that paint had chipped around nearly every fastener. There were some instances of minor damage to components, which are part of the

inboard aileron assembly, but which are not made of graphite composite material. Torn or missing lightening hole covers for the aileron front spar were noted on all four TWA ailerons. These were replaced with spare covers. These minor damage incidents do not reflect on the graphite aileron serviceability, but are indicative of the potential for in-service damage of this component.

These results indicate that the graphite/epoxy components perform satisfactorily in the high utilization environment of commercial transports. The satisfactory structural performance of the ailerons and the absence of damage or defects verifies the structural and durability data obtained in the composite aileron test program.

TABLE I. CUMULATIVE FLIGHT SERVICE SUMMARY – THIRD YEAR

Operator	Aircraft Tail No. (Lockheed Serial No.)	Date of Delivery	Date of Inspection	Cum. Flt-Hrs at Inspection		Cum Landings at Inspection		Util Rate (Hrs/Day)	Inspection Results Second Annual Inspection	Inspection Results Third Annual Inspection
				2nd Annual Insp	3rd Annual Inspec	2nd Annual Insp	3rd Annual Inspec	Three Yrs Flt Svc Period		
Delta	N736DY (1227)	Mar 11, 1982	May 2, 1985	6634	9631	3744	5287	8.4	No discrepancies observed on either part. Small surface delaminations noted on fiberglass end closure of LH part, and repaired with speed tape.	No discrepancies observed on either part.
Delta	N737D (1228)	May 8, 1982	Mar 12, 1985	6318	8787	3540	4769	8.5	No discrepancies observed on either part.	No discrepancies observed on either part.
TWA	N8034T (1230)	Apr 7, 1982	Apr 8, 1985	6989	10,600	1814	2691	9.6	No damage or defects observed on either part. Minor paint loss noted. Parts were repainted; several torn or missing lightening hole covers replaced on front spar.	No defects or damage to the graphite component. Paint chipping upper and lower surfaces, torn lightening hole covers observed on both parts.
TWA	N7035T (1231)	Apr 29, 1982	May 14, 1985	6650	10,804	1745	2718	9.7	No damage or defects observed on either par. Minor paint loss noted. Parts were repainted; several torn or missing lightening hole covers replaced on front spar.	No defects or damage to the graphite component. Paint chipping noted on upper and lower surfaces of both parts, including a small area around nearly all fastener holes. Torn lightening hole covers on both parts, plus two missing covers on LH part.
Lockheed	(1001)	June 3, 1980 ⚠1		365	376	64	66			
	Totals			26,956	40,198	10,907	15,531			

⚠1 Date of composite aileron installation

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3. Stone, R.H., "Flight Service Evaluation of Advanced Composite Ailerons on the L-1011 Transport Aircraft - First Annual Flight Service Report," NASA Contractor Report 172246, September 1983.

4. Stone, R.H., "Flight Service Evaluation of Advanced Composite Ailerons on the L-1011 Transport Aircraft - Second Annual Flight Service Report," NASA Contractor Report 172483, December 1984.

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15. Supplementary Notes

Langley Technical Monitor: Marvin B. Dow
Third Annual Flight Service Report

16. Abstract

This report covers flight service evaluation of composite inboard ailerons on the L-1011 under Contract NAS 1-15069 for a period of five years. This is the third annual report of the maintenance evaluation program, and covers the period from July 1984 when the second yearly inspections were completed, through June 1985.

Four shipsets of graphite/epoxy composite inboard ailerons were installed on L-1011 aircraft for this maintenance evaluation program. These include two Delta aircraft and two TWA aircraft. A fifth shipset of composite ailerons were installed in 1980 on Lockheed's flight test L-1011. This aircraft is now inactive and inspections were therefore not performed this year.

No visible damage was observed on any of the composite ailerons, and no maintenance action has occurred on any of the composite parts except for repainting of areas with paint loss. Flight hours on the airline components at the time of inspection ranged from 8787 to 10,804 hours, after approximately 3 years of service.

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